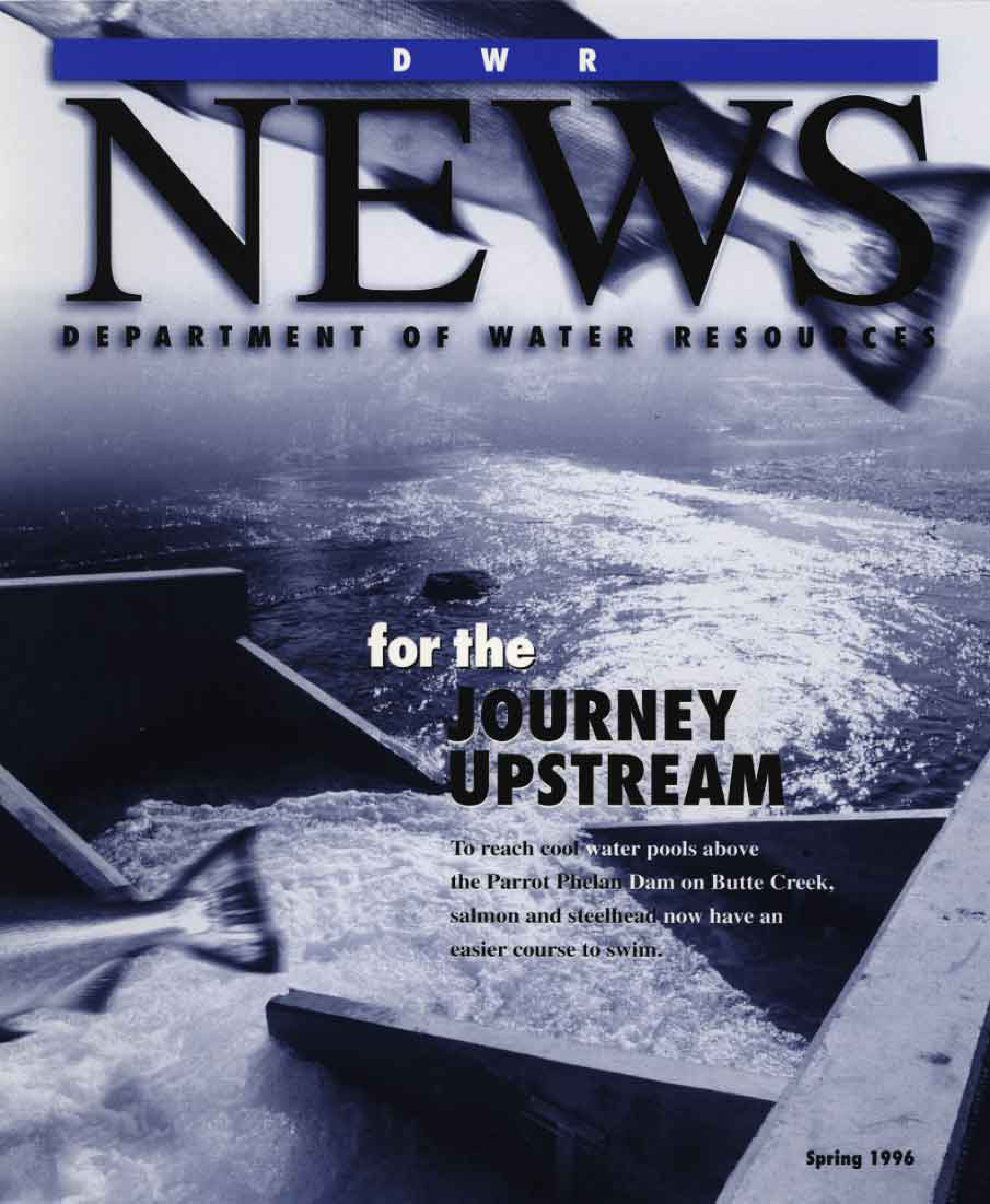
DWR

NEWS

DEPARTMENT OF WATER RESOURCES



for the JOURNEY UPSTREAM

To reach cool water pools above the Parrot Phelan Dam on Butte Creek, salmon and steelhead now have an easier course to swim.

Spring 1996

• • • DWR MISSION STATEMENT

To manage the water resources of California, in cooperation with other agencies, to benefit the State's people and protect, restore and enhance the natural and human environments.

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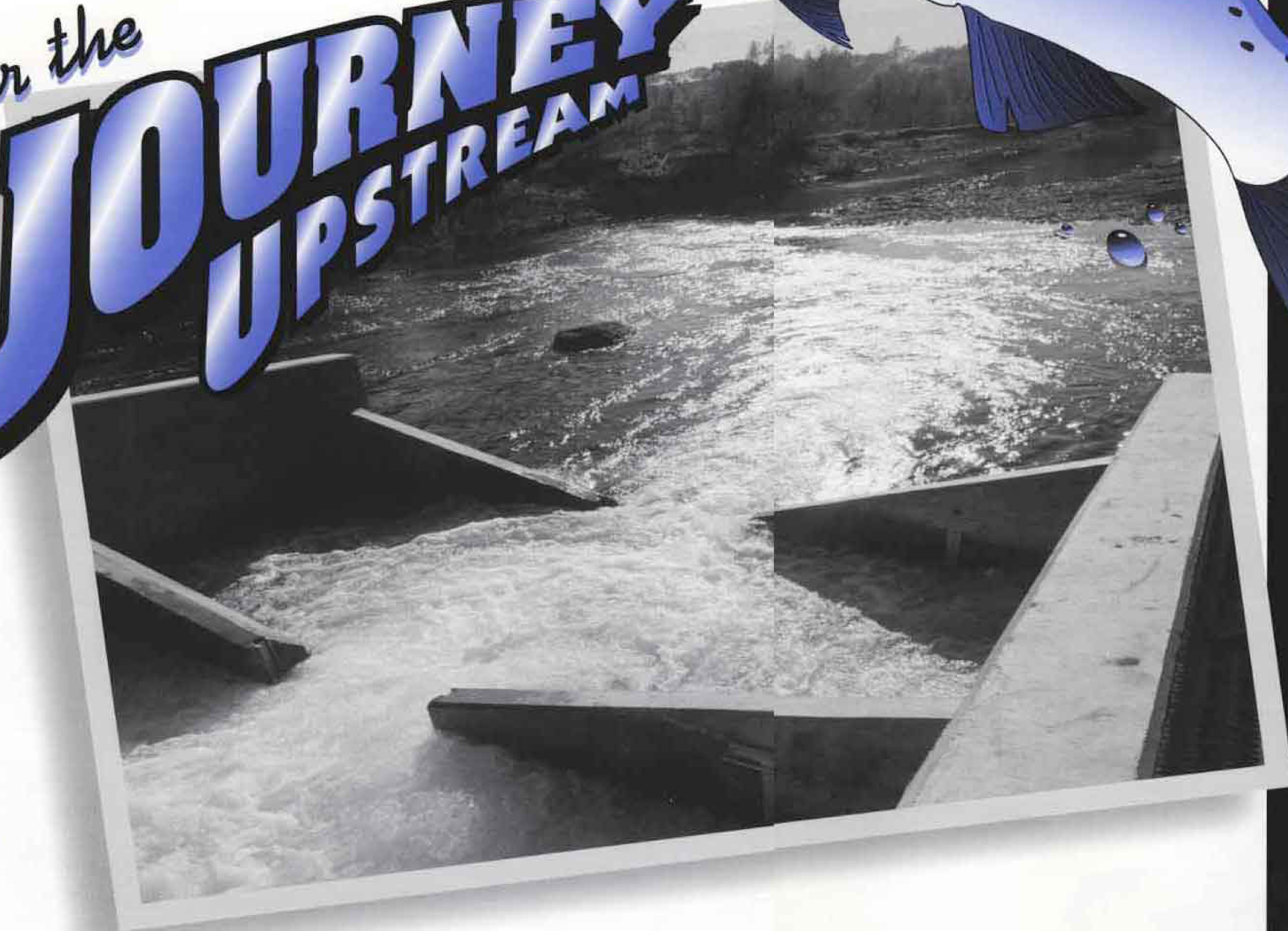


by Pete Weisser

A new kind of fish ladder — the first of its kind in California — will ease the way for salmon and steelhead returning to spawn along Butte Creek near Chico.

Fall and spring-run salmon and steelhead spawn along Butte Creek, home of the new fish ladder. The creek is a tributary to the Sacramento River.

"The new fish ladder is one of a new generation of fish ladders known as 'pool and chute' ladders."

Their upstream migration to reach cold water pools is now aided by a wider and more "fish friendly" designed fish ladder, part of the Parrot Phelan Dam.

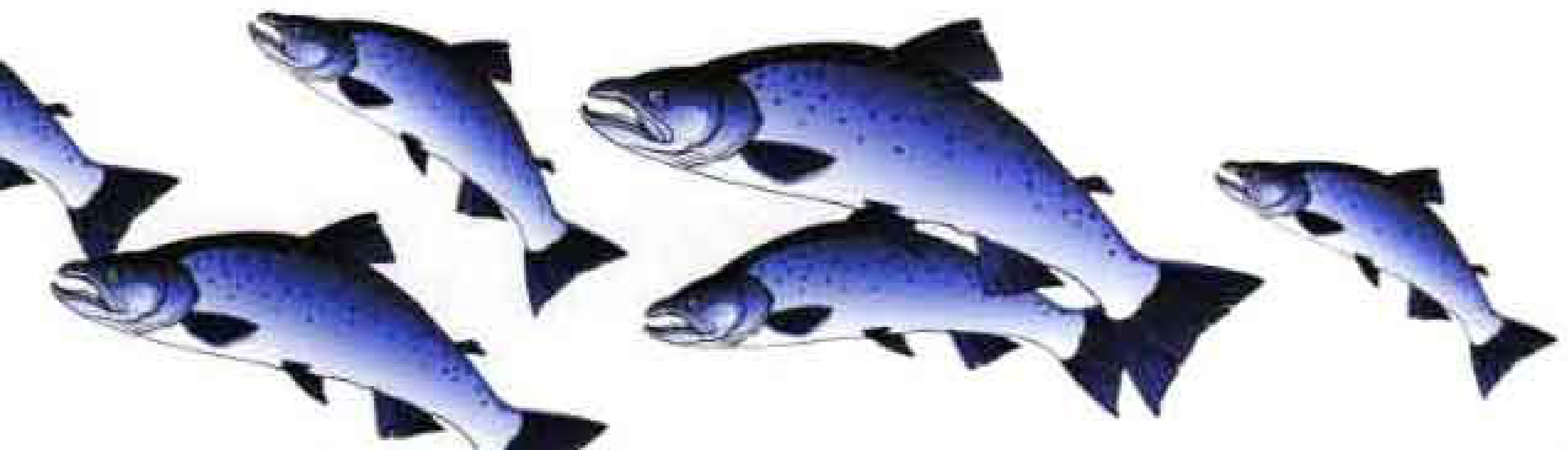
Located on M&T Chico Ranch property, the dam is a privately-owned facility that serves local, state and federal users.

The state-of-the-art, 72-foot-long "pool and chute" ladder represents a $400,000 multi-agency effort to improve migrating conditions for this important salmon and steelhead trout spawning stream in the upper Sacramento Valley.

Butte Creek Salmon and Steelhead

A tributary to the Sacramento River, Butte Creek originates in Lassen National Forest and drains a watershed of about 150 square miles. The creek also supports sensitive populations of both fall and spring-run chinook salmon, and an unknown number of steelhead. Typically, adult spring-run chinook migrate upstream between February and June. They spend the hot summer months in upstream cold water pools until they are ready to spawn in late summer and early fall. Because of their unique life cycle, the salmon need to move rapidly through warmer valley sections of Butte Creek. Injury or delays in reaching the cooler summer holding pools above Parrot Phelan Dam can result in death of migrating salmon before they spawn.

Such a hazard was posed by the marginally passable conditions of the dam's previous fish ladder. Migration was particularly difficult during low flows, causing injury to fish trying to reach the colder waters. Spring-run chinook were especially vulnerable.



To remedy the situation, the California Department of Fish and Game proposed that a ladder be built to improve fish migration in Butte Creek. In response to DFG's recommendation, the Wildlife Conservation Board provided $318,000 in state bond fund revenues to support the project. Additional federal funding of about $100,000 was provided through the Central Valley Project Improvement Act.

New Type of Fish Ladder

The new fish ladder is one of a new generation of fish ladders known as "pool and chute" ladders. Eight pool and chute ladders are currently operating in the state of Washington, according to George Heise, a DFG engineer who worked on the project.

"The pool and chute ladder is unique in that it's a hydraulic hybrid between the conventional step pool ladders, commonly seen at hatcheries and dams, and the baffled, chute-type ladders," says Heise.

"Step pool ladders are limited in the amount of flow that can be passed from pool to pool, making them difficult for fish to find. But they are very easy for fish to move through, once fish have entered the ladder. On the other hand, baffled chute ladders are easier for fish to find but more difficult to move through, due to high water velocities in the ladder."

Heise adds that the unique design of the baffle in the pool and chute ladder permits a strong jet of water to move through the center notch of the baffles, while allowing a plunging pool-to-pool flow along the sloping portions of the baffles.

"The result is the best of both worlds, strong attraction flows to the ladder, and easy fish passage once the ladder is entered."

At 20 feet in width, the new structure is more than three times wider than the old ladder. It features eight pools—each eight feet long—separated by specialized baffles. The baffles have a sloping crest, center notch with adjustable flashboards and orifices with lockable gates. The 20-inch by 20-inch orifices provide an alternative passage route for fish that are reluctant to leap the baffles. They also help keep the outer portions of the pools cleansed of sediment.

The fish ladder is designed to provide excellent fish passage at a wide range of flows, from 20 cubic feet per second (cfs) to 300 cfs. The pool and chute ladder requires little maintenance.

To build the new ladder, the old fish ladder structure was removed and backfilled. A section of the dam, adjacent to the old ladder, was then excavated to accommodate the new one.

A Cooperative Effort

"I'm pleased that DWR and DFG engineers worked together to design this state-of-the-art fish ladder," says David N. Kennedy, DWR director, acknowledging those instrumental in developing its design: Heise, Cindy Watanabe, also a DFG engineer, and DWR engineers Kevin Dossey, Bill Mendenhall and John Peterson.

The process began in 1993 with Watanabe collecting survey data at the site to begin hydraulic analysis and design of the ladder. In 1994 she and fellow DFG engineer George Heise constructed a wooden scale model to finalize the ladder's baffle design and overall dimensions. The model's hydraulic performance was tested at the American River Hatchery near Nimbus Dam. Similar to designs used in Washington, its dimensions were modified to fit hydraulic conditions at Parrott Phelan Dam.

DFG then requested assistance from DWR's Northern District Engineering Studies section to prepare final contract plans and specifications, and to provide oversight and final inspection of the construction project. DWR also agreed to perform topographic surveying and obtained core samples to facilitate the design work.

The fish ladder eases the way for migrating fish seeking cool water holding pools above Parrot Phelan Dam.

A strong flow can move through the baffles' center notches.

DWR engineers Dossey, Mendenhall and Peterson performed concrete and steel design calculations and modified the preliminary designs to fit the conditions at the site. They incorporated concepts discussed at meetings with DFG and M&T Chico Ranch staff, who will be responsible for operation and maintenance of the ladder. In March 1995 the DWR engineers, working with senior delineator Michael Serna and student assistant Allen Boyd, completed the final ladder designs, drawings, specifications, quantity calculations, and cost estimate.

DFG awarded the construction contract to Deide Construction, Inc. of Woodbridge. Construction began on July 26 and was completed in November. Now in service, the new ladder is working well.

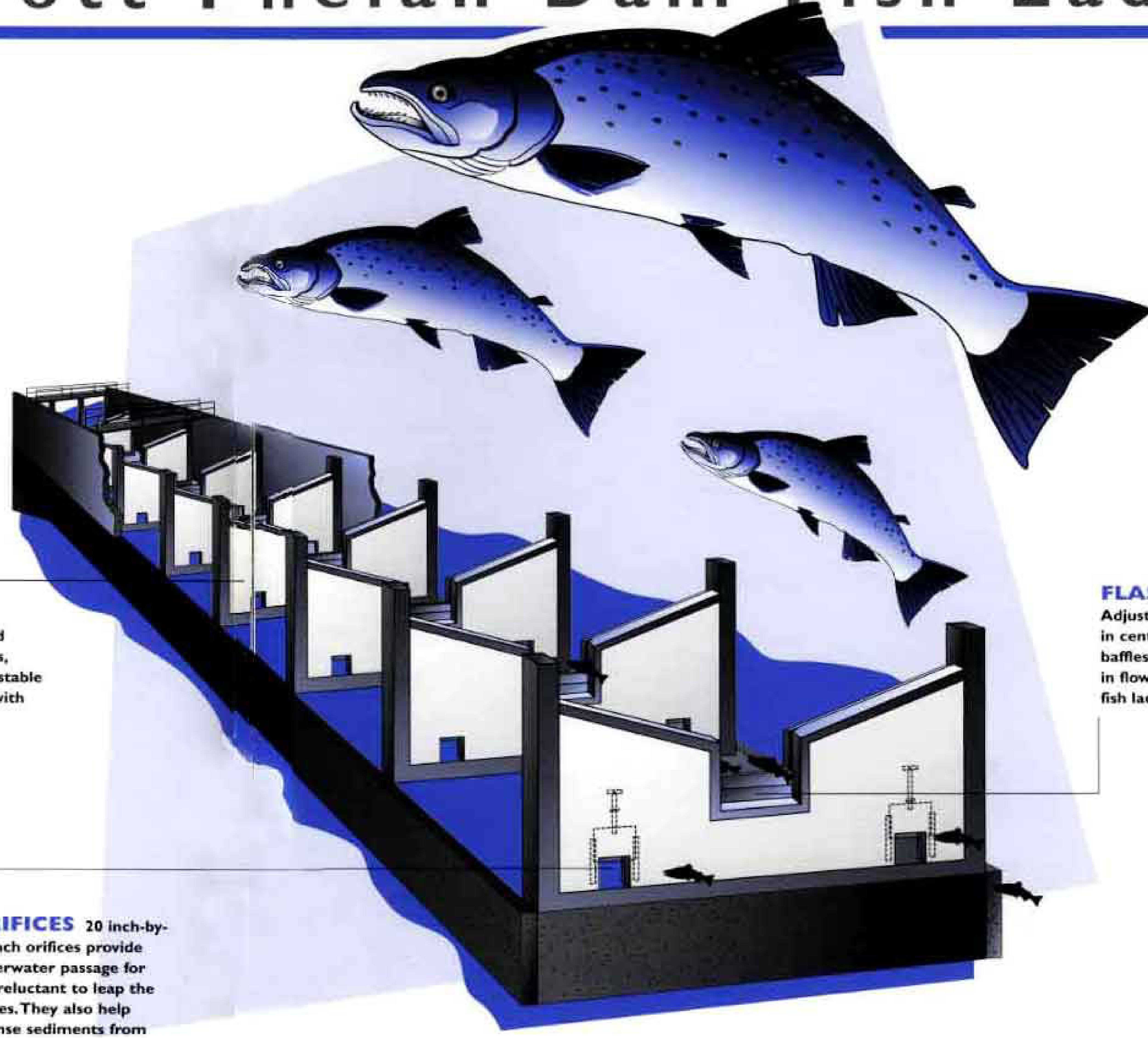
Ranch Responsibilities

M&T Chico Ranch is no stranger to its new responsibilities as caretaker of the new fish ladder. In fact, its management has a track record of environmental commitment noted by water and wildlife officials. Ranch manager Les Heringer Jr. was commended by state officials for his support of the project. This year, Heringer also received a Certificate of Special Congressional Recognition and was named "Man of the Year" by the Butte County Farm Bureau.

The ladder is located on M&T Chico Ranch, whose staff is known for their commitment to the environment.

In 1994, DFG presented a Wildlife Conservation Award to two other M&T Ranch managers, Sally Hearne and Jim Shanks, for work to revegetate Delta levees on M&T's Staten Island Ranch property in San Joaquin County. The revegetation was done in ways hospitable to Delta wildlife.

Parrott Phelan Dam Fish Ladder

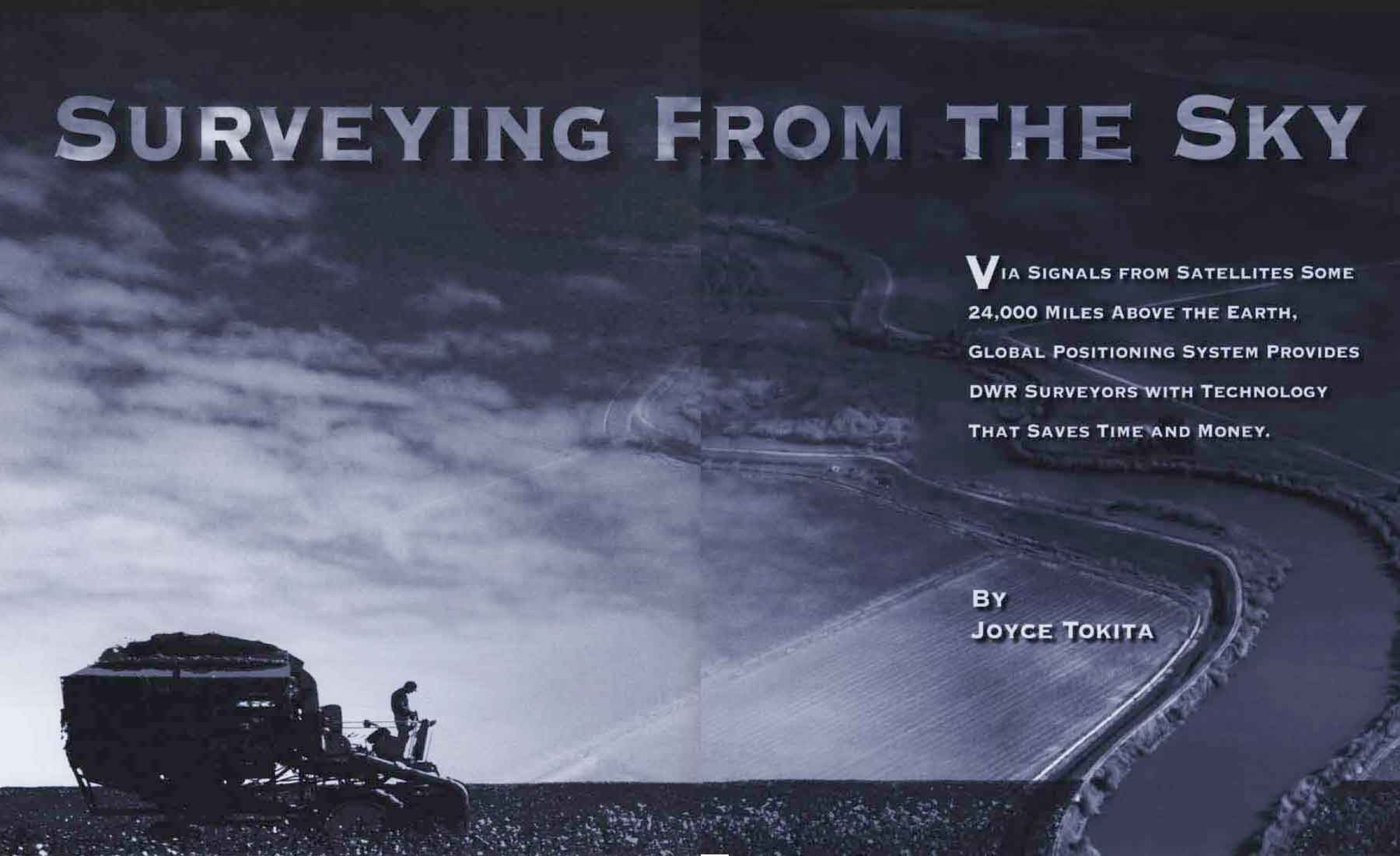


BAFFLES Specialized baffles have sloping crests, center notches with adjustable flashboards and orifices with lockable gates.

FLASHBOARDS Adjustable flashboards in center notches of baffles allow variations in flow levels along the fish ladder.

ORIFICES 20 inch-by-20 inch orifices provide underwater passage for fish reluctant to leap the baffles. They also help cleanse sediments from outer portions of the pools.

SURVEYING FROM THE SKY



VIA SIGNALS FROM SATELLITES SOME 24,000 MILES ABOVE THE EARTH, GLOBAL POSITIONING SYSTEM PROVIDES DWR SURVEYORS WITH TECHNOLOGY THAT SAVES TIME AND MONEY.

BY
JOYCE TOKITA

When Echo, the first TV satellite, was launched in 1960 so was space-age technology for the masses. These earth-orbiting communication links "shrunk" the world and brought televised images of distant lands into our living rooms, expanding the boundaries of our global and personal realities.

Today, satellites have an even greater impact on our lives. They gather intelligence for our military, record and track weather systems, and monitor tropical rain forests, oceans, deserts and other natural phenomena for changes and trends in our environment. Via their signals, we can view a television program from Russia, hear a radio broadcast from England, and phone a friend in the Orient.

Add to those advances the Global Positioning System, a relatively new and sophisticated surveying technology that is revolutionizing our world and the way we find our way in it.

During the Gulf War, soldiers used handheld GPS monitors to pinpoint their location in the desert. For years, boaters have used the system to navigate and fix their positions at sea. Oldsmobile buyers can now opt for digitized road maps built into their dashboards. With the aid of a GPS receiver, lost drivers can instantly see where they are and ask for directions to their destinations.

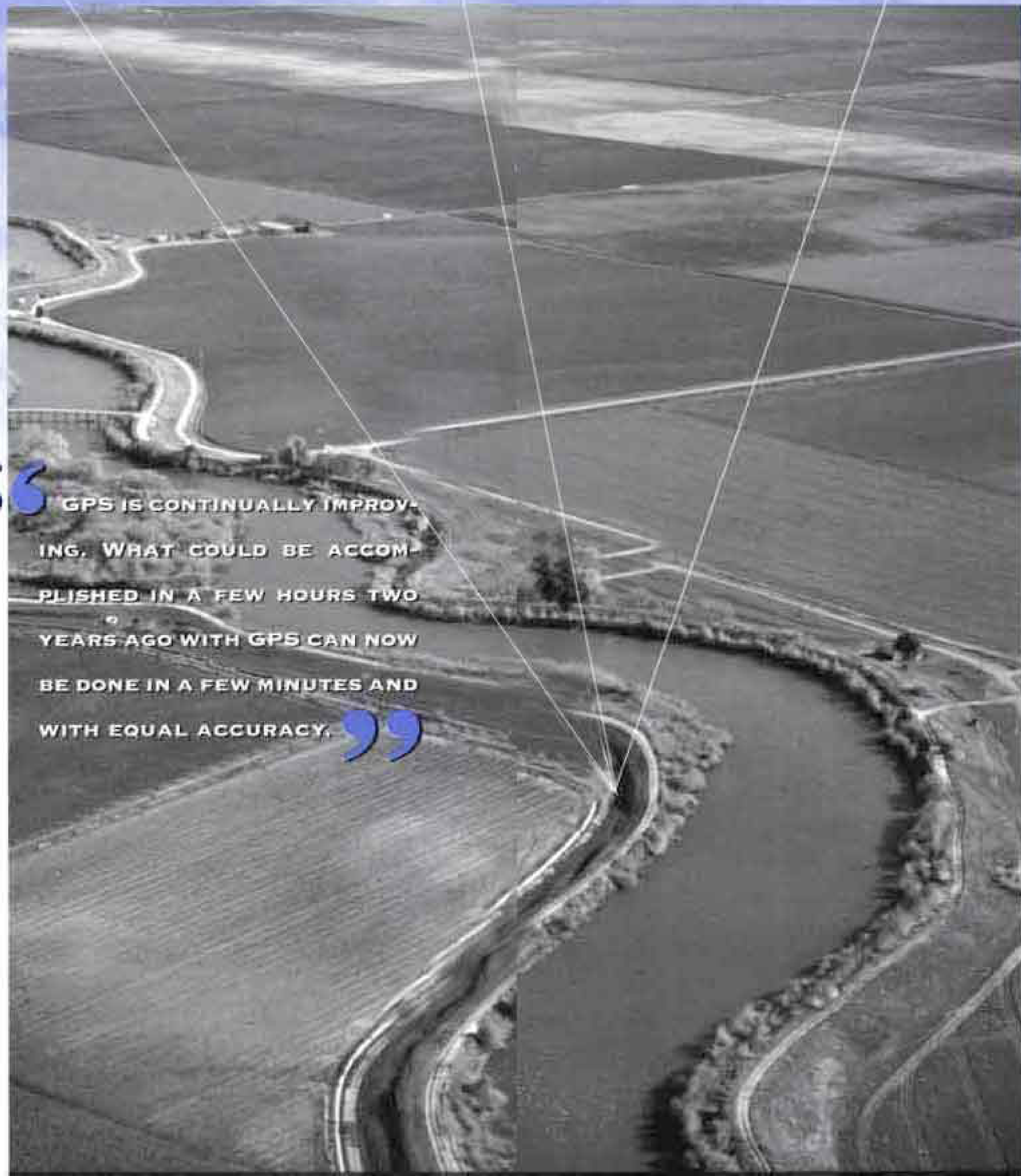
GPS technology has also introduced dramatic changes in the way DWR and its surveyors conduct their business and in the process has saved thousands in dollars and hours.

GPS and its Uses

A brain child of the U.S. Department of Defense, GPS was created in the 1970s as a navigational system for military operations. Using signals from 24 satellites in fixed orbits some 24,000 miles above the earth, the system can provide its users (such as airline pilots, boaters and land surveyors) with data to determine their three-dimensional position (longitude, latitude and elevation), velocity and time, almost anywhere in the world.

Put simply, GPS works partly by timing how long it takes a satellite radio signal to reach a receiver, then calculating the distance from that time. By picking up and comparing signals from at least two GPS receivers, a surveyor can calculate a position to within subcentimeters.

"That's what advertisements claim," says Garry Weldon, chief of DWR's cadastral surveys and land records, of the technology that the Department has used since the late 1980s. "GPS is continually improving. What could be accomplished in a few hours two years ago with GPS can now be done in a few minutes and with equal accuracy."



With signals from two or more satellites, GPS provides precise surveys to monitor subsidence of Delta islands and levees.

The system also provides continuous coverage, with signals from up to nine satellites available at any time—a situation that wasn't always so. "At one time, only four satellites were visible for four hours a day, at specific times...and you had to be there, even if that meant at 4 a.m.," says Paul Ladyman, who heads field surveys for the Department.

With GPS comes other benefits. Because the "eyes" of GPS are high above the earth, sight barriers such as mountains, trees and buildings are less of a problem for surveyors. (A clear sky or horizon is requisite for receiving the satellite signals.) "But its signals can be obscured by high corn fields, orchards or forests," Ladyman explains.

Recent advances, however, have diminished the problem. An "on the fly" device compensates for such obstructed readings via radio waves which supplement the satellite signals so the surveyor doesn't lose a value when he or she goes under a structure like a bridge. "Before you had to stop and spend several minutes reestablishing the value," says Weldon.

Because of its speed and precision, GPS technology is used in nearly all DWR surveys. "It is becoming such a common tool to surveyors who in turn are constantly providing feedback to manufacturers about problems encountered. The result is that there is always something better on the market."

Delta Benchmarks

One of the more impressive uses of GPS took place in the Sacramento-San Joaquin Delta, the heart of California's water system from which 20 million residents receive a portion of their drinking water. Using GPS, DWR surveyors conducted precise surveys to reestablish the region's network of benchmarks. These benchmarks are more or less stable locations with established elevations that serve as vertical control points for surveying other locations or structures such as levees.

The network, consisting of more than 100 benchmarks in and around the Delta, can be monitored to detect the effects of subsidence, tectonic anomalies and other events which cause movement in the earth's surface.

Benchmarks serve as reference points of known elevations in the Delta, where physical features such as levees and islands are continually moving due to such factors as subsidence and precipitation. Reliable benchmarks are essential for making comparable measurements such as those for flows and tides. "The benchmarks serve as a common ground from which to

compare measurements, say of the effects of a high tide on levees in two different regions of the Delta," says Howard Mann, a senior engineer who's part of the data section responsible for conducting Delta water measurement surveys.

"The benchmarks also help us monitor scouring or sediment buildup in Delta channels. They're indispensable to measuring the elevation of almost anything."

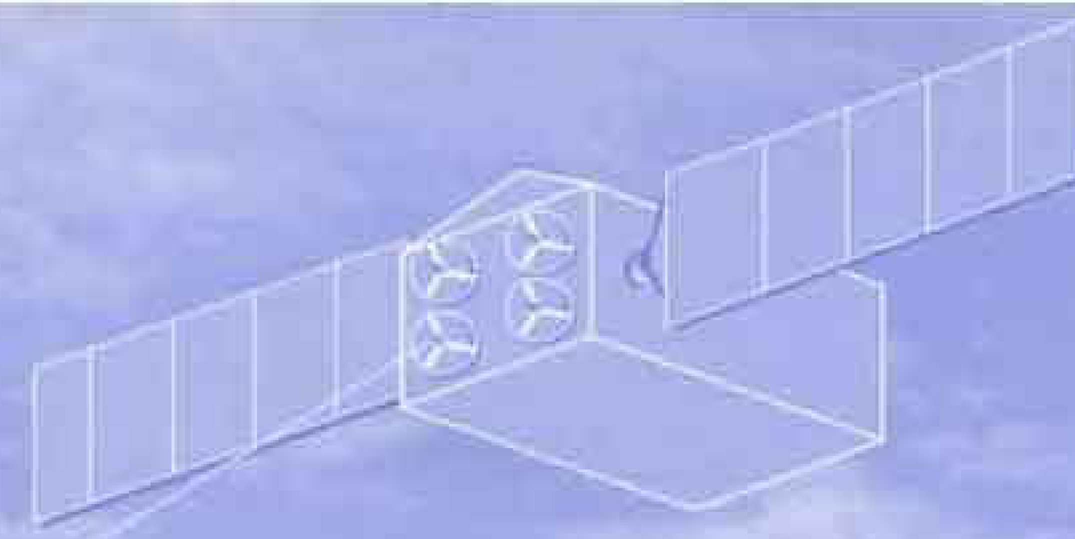
Before GPS, however, Delta benchmarks were far from being functional and often inaccurate.

"Previously, the benchmark measurements obtained from standard survey methods were marginally accurate to unacceptable," says Rosendo Mendoza, a land surveyor who processed all the data for the Delta benchmark project. "Now we have repeatable, verifiable datum from which we can remeasure to determine the variations of the benchmarks' locations over time. This means we can accurately gauge tides and calculate subsidence rates and magnitudes that impact the construction of levees and other flood control structures in the Delta."

The standard surveying methods using spirit levels require intervisibility between sites, that is the ability to see between points where readings are done. For GPS, intervisibility is not a requisite condition. If receivers can pick up satellite signals, survey readings can be completed.

"Using spirit levels can be very tedious because you must get level readings that are precise," says Mendoza. "At the most, the distance between points can be 60 meters. On a good day, you can survey 2-3 miles, but if the terrain is steep, it's much slower going. With GPS, points can be as much as 2 miles apart, and terrain isn't a problem unless something blocks the satellite signals."

A project like surveying Delta benchmarks would have required at least two crew years to complete using standard surveying methods. With GPS, it was done in about 45 crew days. The end result was a cost savings of more than 95 percent for the Department.



Thanks to GPS, reliable benchmarks were established in the Delta (left page). The project took about 45 crew days to complete, compared to at least two crew years using standard surveying methods.

Coastal Surveying

Although not all of the terrain surveyed for the 100-mile-long Coastal Branch Aqueduct lent itself to GPS use, Paul Ladyman says it helped in some sections. "Much of the land along the alignment is very rugged with very steep ravines. Where there was a clear horizon and no trees or bushes overhead to block signals, GPS was valuable."

But when surveyors could not drive to the site and had to hike in for long distances, the GPS technology proved somewhat cumbersome. "The receivers (smaller than a briefcase) are getting lighter, but the weight of that piece of equipment with all of the attachments needed (antennae, batteries, cable, etc.) can be as heavy as 30 pounds," he adds.

Where GPS was practical (no obstruction overhead for signals and ready access to the site), surveyors could do in hours what would take a week to complete with more conventional equipment.

Where it was practical, GPS was used to survey the rugged terrain along the Coastal Branch Aqueduct.

Cost Savings

Such savings in staff time and costs is just one reason why the Department has not limited its use of GPS to surveying the route along the Coastal Branch Aqueduct or establishing elevation points in the Delta. GPS has proven its worth in a variety of projects including monitoring subsidence along the State Water Project, tracking horizontal movements in the earth near facilities close to seismic areas, mapping contours of channels along the Mokelumne River for planning efforts, plotting well sites, and, more recently, calculating amounts of sediment that entered the California Aqueduct during the 1995 Arroyo Pasajero flooding and locating sediment concentrates in the canal.

"The savings from such survey work are tremendous," says Garry Weldon. In aerial surveying, for example, GPS has eliminated the laborious field work once needed to set lines of white crosses on the ground to guide the plane's flight path.

"The technology has basically eliminated the field work," he says. "All you need now are a few major points to set up GPS receivers. With another receiver in the plane, you could know your location exactly to the nanosecond each time the camera clicked."

Not only did GPS reduce the crew time needed for aerial surveying, it also removed the environmental impacts, and thus the related restrictions, the field work would have caused. "Plus we don't have to get rights of entry from property owners," Weldon adds.

The benefits from GPS add up in dollars. "A project which once cost $200,000 can now be done for around $30,000. This is a savings in field time alone. What used to be done by two or three crews of four now takes only two people."

More GPS Uses

Though at DWR, GPS is mainly the tool of surveyors and engineers, its technology has found practical and indispensable applications in many other arenas.

GPS data, when combined with other satellite images and demographic, geographic, geologic and other databases, will prove crucial in groundwater monitoring, urban planning, natural resources exploration, environmental monitoring and data collection—to name a few. Already with the help of GPS, farmers are planting, fertilizing and harvesting their crops; ambulance companies are tracking their emergency vehicles' locations and calculating mileage to and from an accident scene; airlines are monitoring flight paths and altitudes; and construction contractors are inventorying their building materials. Recently, scientists mapped the entire ocean floor, complete with volcanic ranges, trenches, fracture zones, and ridges. The map will not only further our knowledge of the ocean basins, it will also prove to be a boon for commercial fishing, oil companies and global climate researchers.

These advances are mere harbingers of what GPS may have in store for surveying and the sciences. And as its technology becomes more accessible to the layperson, GPS may expand space-age technology's reach past the living room and into the realm of our everyday lives.

WHILE SOME GPS EQUIPMENT CAN BE CUMBERSOME TO PACK AND CARRY, ADVANCEMENTS MADE ON THE TECHNOLOGY ARE INCREASING ITS PRECISION AND PORTABILITY.

GPS IS ALSO USED BY THE DEPARTMENT TO TRACK HORIZONTAL MOVEMENTS IN THE EARTH NEAR FACILITIES CLOSE TO SEISMIC AREAS. ONE SUCH FACILITY IS CASTAIC DAM.

Only A Matter of Time

By
Jeff Cohen

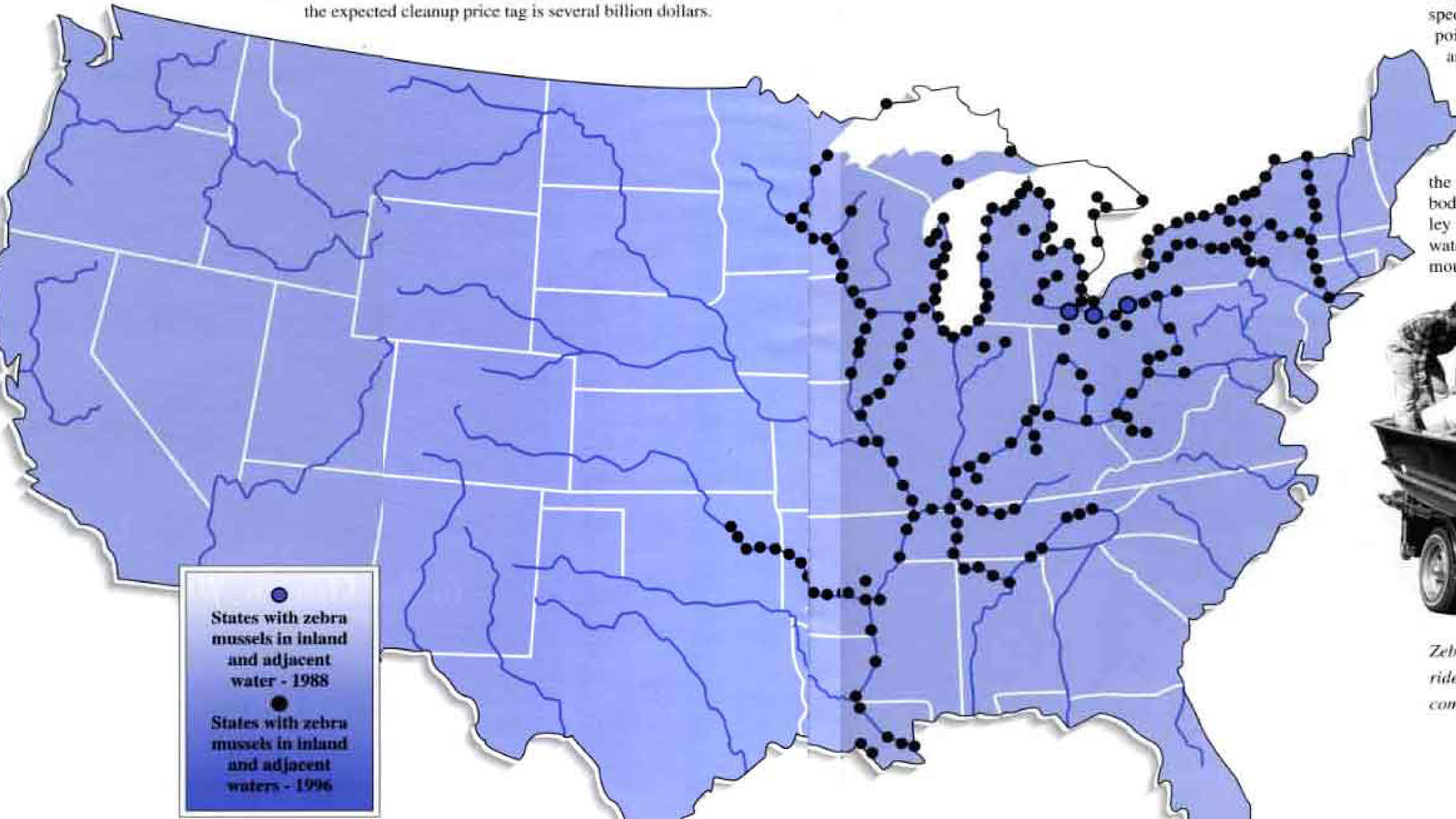
Meet the worst threat to California water systems since the discovery of earthquake faults. It's the "killer bee" of North American waterways, fouling lakes and pipelines from the Great Lakes to New Orleans. What's worse, it's moving out West.

If you're in the water business, sooner or later you'll have to get to know the zebra mussel (scientifically known as *Dreissena polymorpha*). Despite its diminutive stature (barely an inch long fully grown), it can multiply like crazy and clog water and power plant intakes, restrict flows in irrigation pipes to a trickle, and cover reservoir beaches with a crunchy, stinking carpet of shells. Populations can be as dense as 100,000 a square yard.

Getting rid of the black-and-white striped pest can cost water operators plenty. In Eastern and Central Europe, where the mussel has spread over the last two centuries, water project engineers have built duplicate water intakes so that one can be cleaned while the other functions. In the Eastern United States, the expected cleanup price tag is several billion dollars.

How this pest got to the Great Lakes about 10 years ago is a case history for anyone interested in keeping out non-native species that can alter ecological systems. Now that it has come as far as the California border, a warning is being sounded by scientists and water managers that it will probably get into our waterways.

"It will be a great challenge to keep them out permanently," says Dan Peterson, water quality manager for the State Water Project. "Eventually, they will get into California and wind up in one or more of our water bodies. Then it will be no time before they get into the water systems. Water managers must be extra vigilant."



"...if they get into the water projects they could reduce the flow of water in pumps, pipes and canals,"

D-shaped for Disaster?

This nondescript but extraordinary creature originated in the Caspian Sea in Russia and probably arrived in North America in 1986 when a transatlantic vessel emptied its freshwater ballast into Lake St. Clair, between lakes Huron and Erie. Since they were first identified as a problem in the Great Lakes region in 1988, the D-shaped mollusk has spread—mostly by barges and other boats— to a total of 20 states in the East and Midwest, and Canada.

In 1993, when California declared the zebra mussel a prohibited species, the Department of Water Resources worked with the Department of Food and Agriculture to initiate inspections for the mussel. At first, inspectors at border checkpoints (normally used to stop the entry of fruit, exotic plants and accompanying pests) found dead specimens on the hulls of recreational craft transported from the Great Lakes. But more recent findings of live animals heightened public awareness as newspaper headlines in the summer of 1995 sounded the alert.

If boats carrying live mussels find their way to the Sacramento-San Joaquin River Delta or other freshwater bodies, the zebra mussel could spread through the Central Valley Project and the State Water Project, potentially clogging water delivery lifelines for agriculture and cities. High, cold mountain lakes, like Tahoe, and warmer waters in the southernmost part of the state are probably immune from the mussel, which likes temperatures between freezing and 81°F.

Zebra mussels, both live and dead, hitch rides on the hulls of recreational boats coming from infested waters.

If They Get In

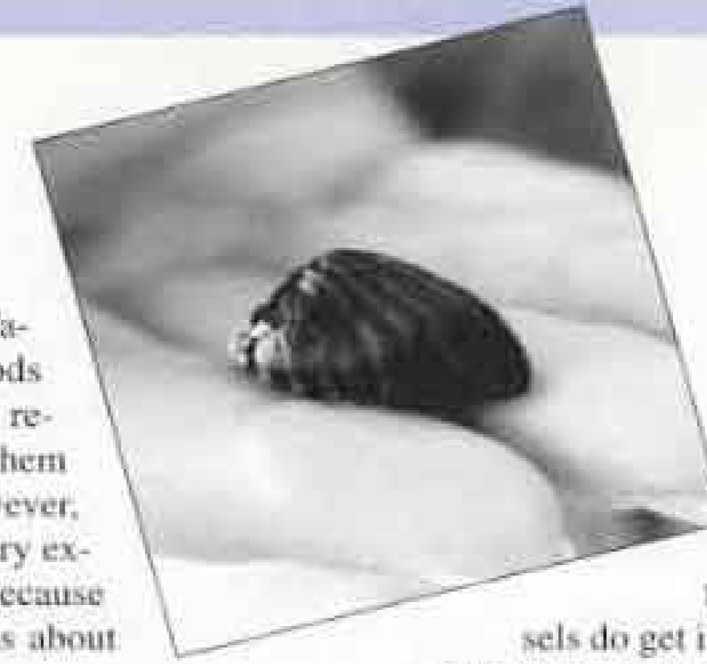
Our major concern is that if they get into the water projects they could reduce the flow of water in pumps, pipes and canals," says DWR biologist Jeff Janik, who is training water quality personnel along the State Water Project to identify the animal. Restricted pipeline flows, loss of head at intakes, obstruction of valves, increased corrosion of steel pipe, and degradation of concrete can result in reduced water deliveries, reduced hydropower production, and increased maintenance costs. Beyond damage to machinery and water operations, zebra mussels could replace native mollusks and upset the ecosystem of the Delta, rivers, lakes, and reservoirs. Zebra mussels filter huge amounts of plankton and other organisms from water (they filter the entire volume of Lake Erie each day), increasing water clarity and causing explosive weed growth.

What makes the mussels so tenacious is their ability to latch onto virtually any surface with gluelike threads. They thrive particularly well in shallow, algae-rich water, and will stick to concrete, wood, and steel. They are very fertile. One female can produce up to one million eggs a year.

California's Challenge

Once established, the zebra mussels are nearly impossible to eradicate. They have few natural enemies, and no commercial use such as human or pet food has been found. Several effective methods have been used to destroy them without damaging other aquatic life. The method most widely used by many water agencies and utilities in the eastern U.S. and Canada injects chlorine in small doses into the pipelines.

Removing zebra mussels by spraying them with hot or high-pressure water can be expensive and not completely effective, depending on the size of the project and concerns about environmental impact.



If infestation occurred in the State Water Project, a combination of methods could be used, including mechanical removal through suctioning or spraying them with hot or high-pressure water. However, control methods would probably be very expensive and not completely effective because of the size of the project and concerns about environmental impact, says Peterson.

And when they die, they're still a big nuisance, giving off the odor of decaying flesh, according to those who have fought their spread in the East.

To identify and control zebra mussels before they spread, monitoring is taking place at locations in the Delta and elsewhere in California. The state Department of Fish and Game is looking for zebra mussels while watching for Asian clams, another exotic species, at several places in the Delta. The federal Bureau of Reclamation, operator of the Central Valley Project, is placing concrete tiles at water intakes and will monitor the tiles for the mussels' presence. State Water Project environmental staff have been trained to identify them and take samples. A risk assessment is being conducted in the State Water Project to learn how vulnerable each facility is to mussel infestation.

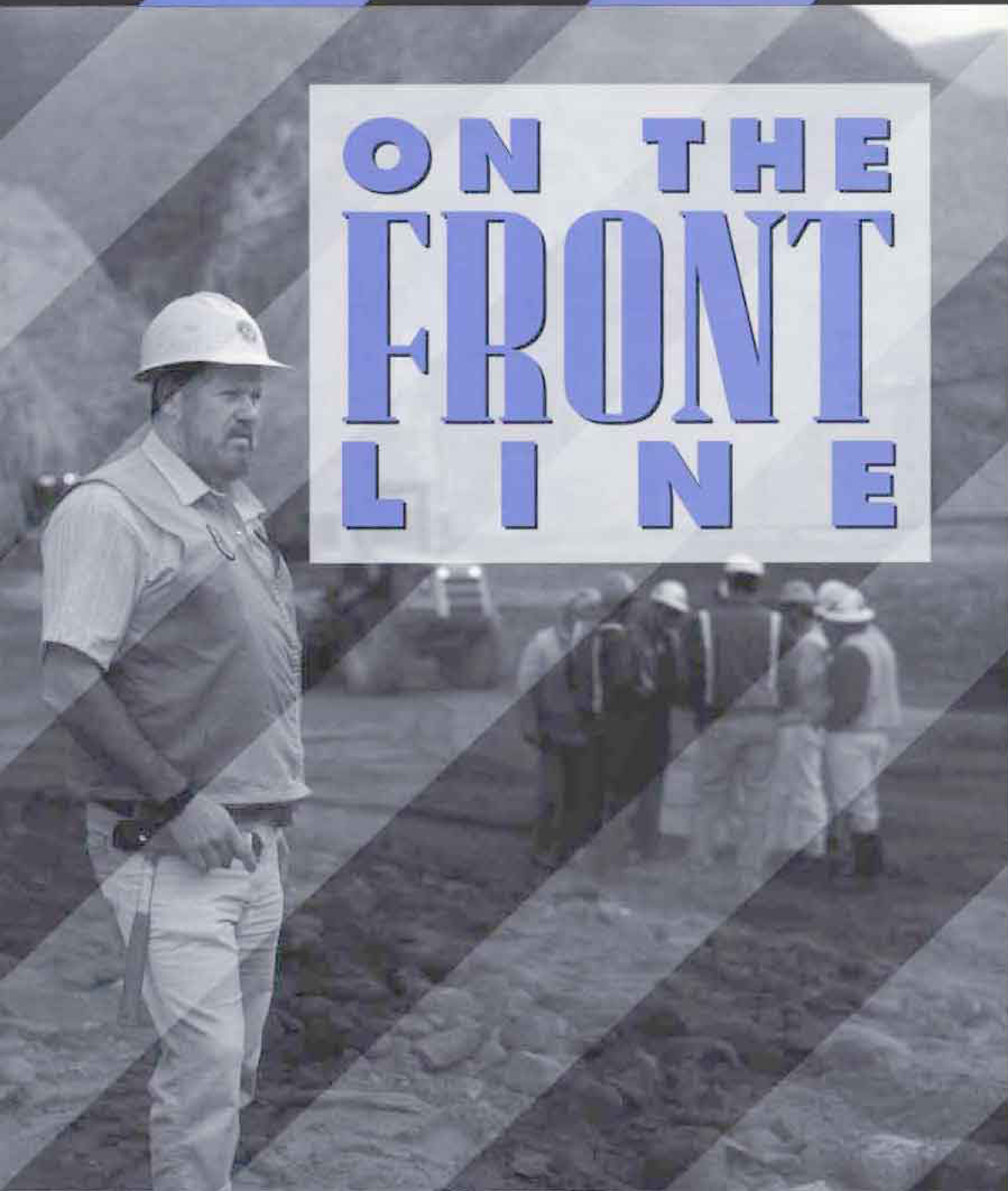
Meanwhile DWR, which played a major role in having zebra mussels listed as a species prohibited for importation to the state, has assumed the coordinator's role in the state's zebra mussel effort. DWR has brought in federal and other western states' support and will continue to look for ways to stop the mussel's entry into the state.

It plans to distribute "zebra mussel alert" posters (similar to one used at the Great Lakes) for State Water Project field offices and water districts. If zebra mussels do get in to California waters, public participation, particularly among boaters, in reporting and collecting samples will be an important way to control its spread. Meanwhile, the search goes on throughout the country for a solution to the zebra mussel problem—and the effort continues to avert a potential crisis for California water systems.

The Zebra Mussel Is Online

The National Biological Service, part of the National Oceanic and Atmospheric Administration, provides an on-line service for reporting zebra mussel sightings. The World Wide Web server (http://www.nfrcg.gov) is available to anyone with access to Internet.

ON THE FRONT LINE



by William Draper

News reports of dam failures and repairs, gate failures, new dams and proposed dams captured headlines last year. This media attention has shined a spotlight on a group of engineers and geologists at DWR's Division of Safety of Dams. Their charge is to ensure the safety of more than 1200 dams statewide through a rigorous monitoring and inspection program. And for 66 years, they have protected California from potential dam disasters.

Combine equal parts diesel noise and fumes with dust generated by huge earth moving machinery. Heat to 100 degrees under a San Bernardino County summer sun and you have a recipe for the Seven Oaks Dam construction site. This is the familiar domain of the Southern California construction worker and heavy equipment operator. But among the workers and machinery at that site, you will also find Richard Baines, Area Engineer and 16-year veteran of the DWR Division of Safety of Dams. Seven Oaks will be a zoned rockfill dam when completed in 1999, and Baines has been following the Seven Oaks project since 1992, long before construction began.

A few miles south in Riverside County, another DSOD engineer, Jim Veres, is tasting the dust of another massive dam construction site. This is Metropolitan Water District's much publicized Eastside Reservoir (formerly Domenigoni Reservoir) currently under construction and scheduled to be completed before the end of the decade.

These are two of the largest dams currently under construction in California. It is DSOD's responsibility to certify the safety of these dams upon their completion, and, understandably, DSOD employees play an active role throughout construction.

"You're there to see that plans and specs are being enforced," says DSOD engineer Jim Veres. "Making sure that work is done properly now to avoid problems later."

Although he cannot be there all the time, Veres is on the site at critical stages to inspect work before it can go on to the next phase. He usually combines his trip with another project up the road: Railroad Canyon Dam, which is being modified to increase storage capacity. It is customary that DSOD engineers work on several construction projects at a time. For some, construction occupies most of their time.

"Last summer, I had seven construction projects," says Richard Baines, referring to his sometimes nightmarish travel schedule. "Sometimes I would go from Sacramento to the northern part of the state, drive to Reno, catch a plane to San Bernardino, fly back to Reno, maybe go back north, and come home."

Y-Nhi Dang Easler is one of DSOD's engineers responsible for monitoring design modifications to dams under their jurisdiction.

Some engineers, like Baines, spend 40 percent or more of their time on the road, although their travels from the Sacramento office are usually limited to one geographic area of responsibility. DSOD has divided the state into nine geographic areas with at least two engineers assigned to each area. When not visiting construction projects, the engineers are inspecting existing dams. On average, there are 140 dams per geographic area, each requiring an annual inspection to ensure it is in good condition and properly maintained.

"Last year I did 80 maintenance inspections," says Jim Veres. "The smaller dams, you can do two, three, sometimes four a day, depending on the travel time. Larger dams may take a half day to a day.

"A simple earthfill dam you can do fairly quickly. You're going up and down the slope looking for settlement cracks and seepage. We try to identify little problems to prevent them from becoming bigger problems."

Housekeeping is the major problem with small dams. Vegetation and rodents weaken the dams. Trees blow over, die, and leave a hole. Squirrels and muskrats burrow into the dams. Overgrown brush attracts the rodents and interferes with the inspection.

"If you can't see the dam, you can't tell if there is anything wrong," says Richard Baines.

More than 80 percent of California's dams are earthen dams. Some are well over a century old, but just because they are old does not mean they are dangerous. Whatever the age, they must conform to current safety standards or be taken out of service.

Engineers Jan Wright (left) and Ben Vanberg inspect work done to stabilize Jackson Creek Spillway at Pardee Dam.

"I feel that (California) dams are in good shape generally," says Vern Persson, chief of DSOD. "Some need attention, but California's dams are in the best condition of any state in the union."

Persson credits DSOD's long history as the reason for the good report card. DSOD was created by the Dam Safety Act in 1929 following the failure of the Saint Francis Dam north of Los Angeles. DSOD's staff of 65 engineers, geologists and support staff watch over more than 1,200 dams of qualifying size[1].

"We give our highest priority to emergencies," says Persson, emphasizing that DSOD drops everything in response to an earthquake or potential dam failure. "Last winter we had several dams that were near failure."

One of those was the Lake Leavitt Dam near Susanville. During the heavy rains last March, DSOD received a call that the earthfill dam was in danger of failing. There was little threat to downstream populations, but a dam failure would have washed out Highway 395. Working with other state and federal agencies, DSOD engineers helped prevent a failure.

Another example occurred in 1994, when DSOD employees received early morning emergency calls following the Northridge Earthquake. Among those responding was DSOD Geology Branch Chief Bill Fraser.

"I was down at Northridge for a week. I looked at 20 dam sites while I was there," he says. In all, DSOD engineers and geologists, working from sunrise to sunset, inspected more than 100 dams during the first four days after the quake. All of the dams were located within 50 miles of the epicenter.

If an earthquake reaches 4.0, DSOD Geology Branch receives a routine notification during business hours, and if it reaches 5.0 or larger, an immediate notification whatever the hour or place. In both cases, Geology contacts the appropriate regional engineers responsible for the areas affected by the earthquake. The engineers identify dams near the epicenter and request the owners to inspect the dams. After major earthquakes (around magnitude 6.0 depending on other variables) the DSOD Field Branch forms inspection teams and conducts inspections in the affected area.

"The Area Engineer has primary responsibility to assess the situation and recommend action," says Persson. "We have emergency field packs assembled with necessary supplies. Since Loma Prieta (the 1989 Bay area earthquake) we've added mobile radios and cellular phones."

Earthquakes command special attention from Bill Fraser and his staff of DSOD geologists. They too may help with post-earthquake investigations, but more importantly, they interpret geologic clues for the engineers assessing new dam sites.

DSOD chief Vern Persson (standing) and engineer Sharon Rakow discuss a three-dimensional model which will be used for seismic analysis of a concrete arch dam.

[1]DSOD has jurisdiction over all non-federally owned California dams that are 25 or more feet high storing more than 15 acre-feet, or more than six feet high storing 50 acre-feet or more.

Chief Persson (third from left) reviews plans for repairing an embankment dam with staff engineers (left to right) Donald Babbitt, Clifford Namura and Sharon Bakow.

"Earthquakes present our dam engineers with challenges not encountered in most other states," says Fraser. "We tell our (DSOD) engineers the earthquake parameters that we feel a site should be designed to withstand. This has probably been the branch's most important role," he says.

And that role is not restricted to new construction projects. As geologists learn more about seismic activity, they apply those lessons to existing dams too.

"We must determine whether a fault is active or not," says senior geologist Jeff Howard explaining that DSOD considers a fault active if it has moved within 35,000 years. DSOD then applies what Howard calls a "maximum earthquake scenario."

"You derive a maximum earthquake magnitude for a fault. You assume a scenario that it would occur at the closest point to the dam site, and you estimate what sort of ground motion would occur at the site resulting from an earthquake at that location. Based on that, you can evaluate whether the dam will be damaged and then determine what preventive action is needed," he explains.

For new dam construction, that information is passed on to the DSOD Design Branch, where Steve Verigin works as a supervising engineer and section chief.

"Design engineers review plans, specifications and other reports for new dams or alterations to existing dams. We're kind of a 'building code department' for dam construction. Currently I have 70 projects in my section."

Verigin explains that as a dam moves toward construction, engineering consultants submit plans and specifications to DSOD's design engineers for review and approval.

"They submit designs which we analyze, and if necessary, we negotiate changes," he explains. "The consultants have learned to involve us early so that we don't become an obstacle. They'll submit plans that are 60 percent complete, and then 90 percent before final design is submitted."

Verigin's section reviewed the Los Vaqueros Dam design, now approved and under construction, with a scheduled completion date of 1997. Los Vaqueros, which is located near Byron next to the Delta, will be a 200-foot-high earth embankment dam capable of storing 100,000 acre-feet of water for Contra Costa County. Construction began in October on the spillway and outlet tunnel.

"We approved the application June 22 after working with the designer on it for three years," he says. "We monitored testing of materials in order to evaluate how the rock and soil will behave. We descended into large borings to investigate foundation rock at 50-60 feet below the surface.

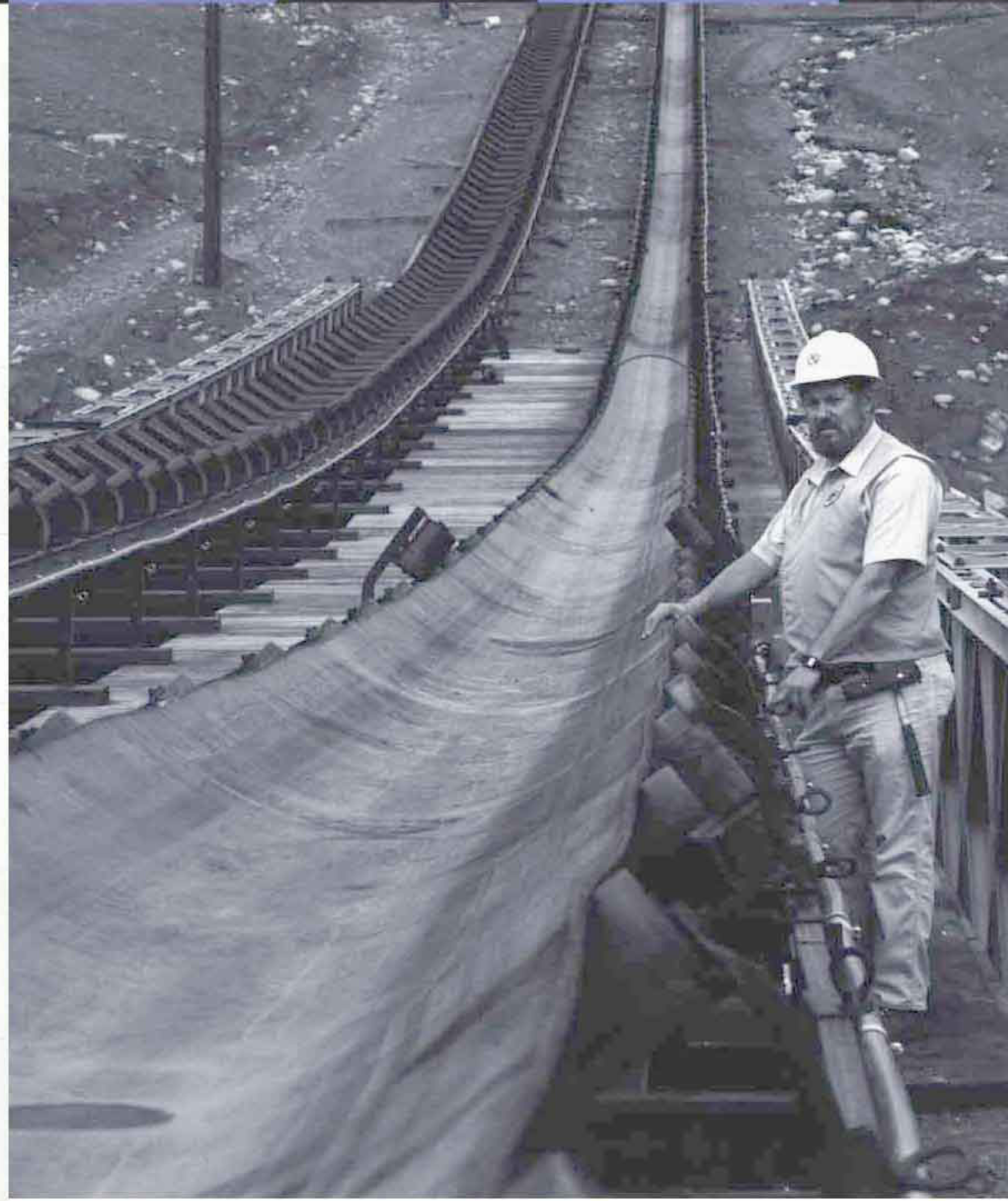
"We look for problems with stability, seepage, settlement from earthquakes, spillway hydraulics, outlets, tunnel lining, anything related to the safe operation of the dam."

During the design stage, the design branch engineers have primary project responsibility for DSOD. Working with the field engineer and the geologist, they coordinate site explorations, field trips and other work to assess initial site conditions. Prior to construction, a reviewed application is routed through the Design Branch, Geology Branch, Field Branch, and Instrumentation Section for final concurrence. After the application is reviewed by the division chief, lead responsibility transfers to the Field Branch and a regional engineer takes over project management. According to Vern Persson, the checks and balances in the system have been refined after years of experience, although he and his staff are continually tweaking the system.

"Things happen to change our focus from time to time. Hydraulic fills were a focus after Lower San Fernando Dam was damaged in the 1971 earthquake. Radial gates are currently an issue after last summer's Folsom Dam gate failure. There are natural disaster type events that happen which focus attention to special issues," he says. But Persson does not foresee any major changes at DSOD.

"What we do now works," he says. "And there's an old saying that if it isn't broken, don't fix it."

DSOD engineer Richard Raines inspects conveyor belts, 2.5 miles long, that will bring materials to the Seven Oaks Dam site near the city of Highland in San Bernardino County.



Sound Barriers

BY
Joyce Takata

It may not be music to their ears, but sound waves may prove to be a lifesaver for young chinook salmon travelling through the Delta. Studies conducted near the confluence of the Sacramento River and Georgiana Slough since 1993 show promise for acoustical barriers, designed to discourage fish from taking a detour on their way to the Pacific Ocean. Such a wrong turn could mean life or death for these young fish whose numbers have declined in recent years.

THE PROBLEM

As juvenile chinook salmon migrate out to the ocean from spawning and rearing grounds in the upper Sacramento River, they must traverse the Sacramento-San Joaquin Delta. There the young fish, about three inches in length, must navigate a complex network of winding waterways, some of which eventually lead to the San Francisco Bay and the Pacific Ocean. In ocean waters, they will feed and mature for two to three years before returning to spawn in the river of their birth.

Not all complete their journey to the sea. Studies have shown a 50 percent higher mortality rate for fish that enter the interior Delta. Death may result from increased predation, the longer distance travelled to the ocean, and losses directly or indirectly related to State Water Project and Central Valley Project export pumping and other diversions in the region.

continued...

Such a detour lies at the fork of the Sacramento River and the Georgiana Slough, located near the town of Walnut Grove. If fish veer into this 12-mile-long waterway, their path will take them to interior channels, decreasing their chances of finding their way to the San Francisco Bay.

DWR, working with other state, federal and local agencies (in particular the San Luis and Delta-Mendota Water Authority), is exploring the potential of using an invisible barrier of sound waves to keep fish from entering the slough. Such efforts may help improve the survival and reduce the incidental take of the endangered winter-run salmon, as well as protect and restore all salmon races.

A Possible Solution

Proposals to place physical barriers in such channels as the Georgiana Slough have met with concerns about creating adverse effects on water quality, altering the natural flow of water from the Sacramento River to interior Delta channels, impeding upstream migration of adult fish, and creating an obstruction for recreational boaters.

So during May and June of 1993, an interagency team, made up of state, federal and local agencies (see **An Interagency Effort**), inaugurated a pilot hydroacoustic salmon guidance project. Its main goals were to evaluate the system's effectiveness in guiding juvenile salmon and its potential adverse effects on salmon, delta smelt, splittail, and other species.

When the barrier is in place, orange buoys mark the spot where 21 underwater speakers generate sound waves meant to guide juvenile salmon away from the entrance of Georgiana Slough. Under each buoy, strung about 30 feet apart, is suspended a speaker at a depth of about 12 feet.

The speakers are connected to an onshore computer-controlled sound generation and monitoring system capable of producing up to 800 watts per channel. Each speaker emits a low-frequency cyclic sound signal, a low humming vibration, that studies show has guidance potential—that is, the capability to present a barrier that fish won't cross.

"The first year was a trial year," says Darryl Hayes, a senior engineer coordinating the project for DWR.

When installed, 21 orange buoys mark the spot of the acoustical barrier project.

"We had the equipment on for four weeks. At first, nothing happened but as the barrier was reconfigured, the results showed better guidance. We couldn't say it was successful that year because we were playing with too many variables. But the results were promising."

The most intensive testing on downstream migrating juvenile salmon came in the second year, April to June 1994, with trawling added to evaluate the barrier's efficiency. Two boats towing a Kodiak net between them, trawled at several locations downstream of the barrier in the Sacramento River and Georgiana Slough. At the same time, approximately 12 million hatchery-reared salmon from the Coleman National Hatchery were released in the upper river to coincide with the natural fall-run salmon migration to the ocean. Trawls were done four days each week, two days with the system on and two days with it off.

"The barrier's main purpose is to protect the juvenile salmon migrating downstream, to keep them from entering the Georgiana Slough," says Chuck Hanson, a fisheries consultant hired by DWR to collect field data and analyze results from the acoustical barrier project. "The 1994 data indicated we had a positive and statistically significant guidance effect produced by the barrier that directly reduced the number of juvenile salmon entering the slough. This, we believe, benefitted their improved survival."

"Overall, the barrier had a little more than 50 percent efficiency," adds Hayes. "Under ebb tide conditions, it demonstrated more than 60 percent efficiency. Low guidance was observed under flood tide conditions. These results reflect the complex hydraulic conditions created at the site by tidal action."

Also during the 1994 test, a variety of fish were exposed to the sound waves under controlled conditions. Although those results showed no ill effects to the fish, additional tests are planned to look into the sound's influence on their behavior. (In fall 1995, exposure tests were conducted on delta smelt and splittail.)

Further research was also needed to resolve some concerns about the acoustical barrier, such as why fish released upstream from it appeared to increase their travel time through the area. Testing was to resume in spring 1995, but high flows from a very wet winter made it difficult to install the equipment, which was also experiencing its own technical problems. It was decided to delay these tests until spring 1996

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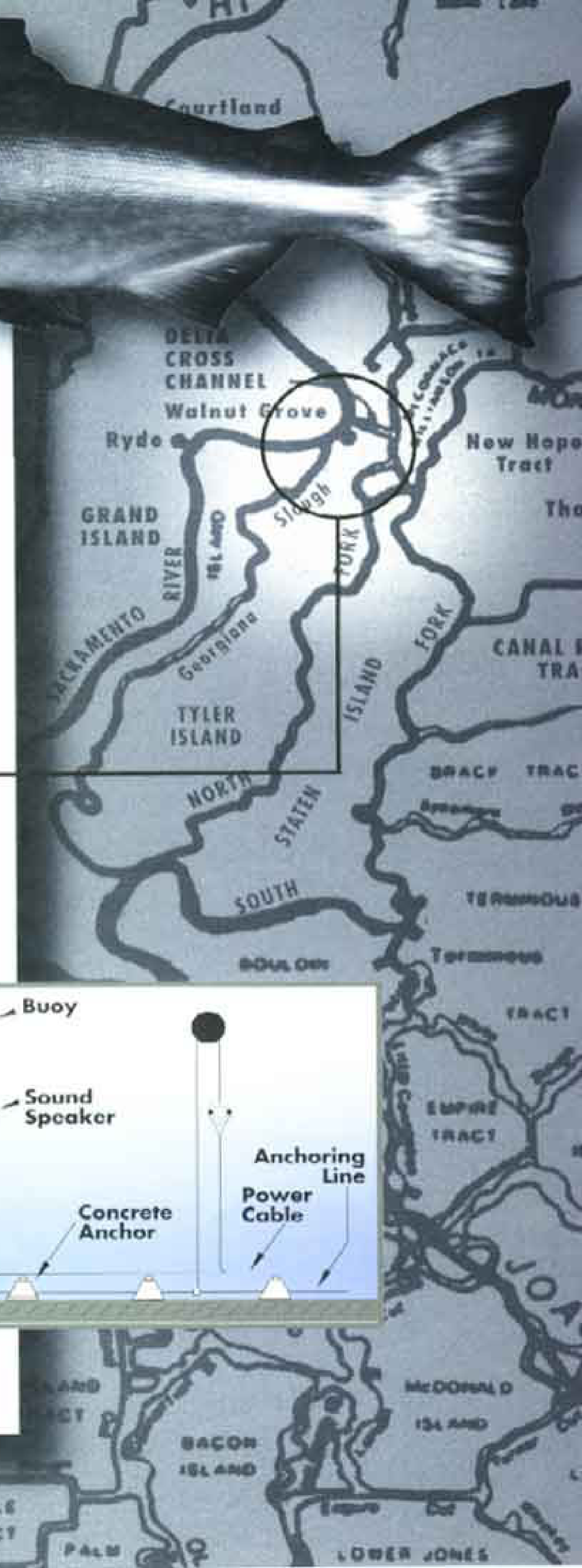

Salmon, migrating from Sacramento River spawning grounds to the Pacific Ocean, sometimes detour into interior Delta channels. The acoustical barrier aims to keep them on course.

The speakers, suspended 12 feet beneath the buoys, emit a low humming vibration that may present a barrier fish won't cross.

and continue other testing in fall 1995. That test, which ran from late October to mid November, concentrated on the barrier's impact on adult salmon migrating upstream to spawn. Radio tags were placed in 100 adult salmon that were released in the river downstream of the barrier. The main intent of the test was to find out if the barrier when turned on (versus its effect when off) would misdirect or delay adult fish as they migrated through the area. Preliminary results show that the acoustic barrier does not block or significantly delay adult salmon from migrating upstream.

"The testing will continue in spring 1996," Hayes says, "during which we hope to have more flexibility in its operation. In early 1996, fishery agencies will review the work on delta smelt and adult salmon migration which addresses many of their concerns."

The Next Step

"Everyone is reserving judgment on the success of the project until after the 1996 results," says Hayes.

Dan Odenweller, a senior fisheries biologist, from the California Department of Fish and Game, believes it's "premature to render a judgment" on the Georgiana barrier test. "It shows promise, but for reasons beyond our control, we haven't fully addressed a number of critical issues such as the barrier's impact on other species and on upstream migrating salmon. We're really not clear about adverse effects, and further studies are required."

Such caution stems from similar tests conducted at other sites that revealed inconclusive or contradictory results. One study, undertaken by Reclamation District 1004 to divert fish from their intake, showed no success in its second year. Testing conducted by other states and countries is still at the pilot study stage.

To add fuel to doubts about acoustical barriers, a report by the former State Office of Technology Assessment (OTA) questioned the use of sound as a behavioral barrier to protect fish. OTA concluded that studies should focus on more preliminary research to first find out how and why sound would even work as a fish protective device.

Despite the skepticism, other agencies find reasons to continue their use and study of sound barriers.

"Though no agency has installed a barrier as the solution to their problem, some states back East are using acoustical barriers as a supplementary guidance system to the fish screens they have in place," Hayes points out. "Also the Corps of Engineers has assembled a number of experts and is attempting to answer some questions with a similar system on the Columbia River."

And as the testing continues at Georgiana Slough, Hayes and Chuck Hanson believe the answers will come.

"What we've found in the past years' studies is that acoustic barriers can be effective but require a substantial amount of site specific work, like collecting information on water velocities and testing the barrier to see if you're producing acceptable levels of fish guidance," says Hanson. "We're not able to extrapolate from one site to another. Each site has different conditions to consider. Acoustical barriers are not something you can simply purchase, place and be assured that they will work."

Both maintain the acoustical barrier at Georgiana Slough still holds promise.

"We're getting closer to having enough data to say whether it does the job or not," says Hayes. "As much as we want to be certain we're doing some good, we also want to be sure we're not doing some bad (adverse impacts to the fish). There's no doubt that more studies are needed, but it's a technology that shows promise."

Crew members from an interagency team set the net for a Kodiak trawl downstream of the barrier.

An Interagency Effort

The project is a multi-agency effort conducted under the auspices of the Interagency Ecological Program. The San Luis and Delta-Mendota Water Authority took the lead in implementing Phases I and II, with the Department of Water Resources overseeing ongoing and future efforts. Other agencies participating in the field work include the California Department of Fish and Game, U.S. Fish and Wildlife Service, and U.S. Geological Survey. The Boat House Marina is providing logistical support.

DWR and the Bureau of Reclamation have contributed the majority of funding from money collected from state and federal water contractors for water delivered from the Delta. The San Luis and Delta Mendota Water Authority, representing federal water contractors, also supplied technical assistance and funding.

PICTORIAL

A Draining Experience

It's a sight few of us will see often, but quite a few did when Pool 7 of the California Aqueduct was drained for repairs. Visible from Interstate 5, the 5.5-mile stretch of canal near Patterson laid dry like a vast concrete canyon, measuring 138 feet across at the top and 40 feet wide across the bottom.

Before the repair work commenced in early December, the pool was gradually emptied, drawing the water level down (30 feet) at a rate of about a foot a day. To keep the section dry, the radial gates at either end were closed and sealed. But progress was a bit delayed by the discovery of eight cars, miscellaneous equipment parts, a safe, and about 15,000 fish, mostly striped bass and catfish, that had to be removed first. California Conservation Corps members, under the watchful eyes of Department of Fish and Game and DWR staff, used 130-foot-long seine nets to salvage the live fish which were then released in nearby watered portions of the aqueduct.

The contractor then moved in to make extensive repairs to Pool 7, to stop leaks that were initially discovered nearly 20 years ago. "The leaks were getting worse," says Sonny Fong, chief constructor inspector on the project. "We had been monitoring the leaks over the years. When we discovered we were losing up to 25 gallons a minute, it was essential that we fixed the problem right away."

Cracked and displaced concrete panels were repaired or replaced. Liquid Boot, which forms a tough rubberized, waterproof geo-membrane when dried, was sprayed over the repaired areas and anchored to the aqueduct lining with a two-inch overlay of shotcrete, a concrete substance.

Powerful and windy rainstorms during mid-month temporarily halted the repair work that continued almost around the clock to meet its Dec. 31 deadline. The job was completed on Dec. 28, and Delta Field Division staff began refilling Pool 7 on Dec. 31.

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